Understanding Energy Footprints

To assist in targeting energy-savings opportunities for energy systems, a series of *Energy Footprints* was developed to map the flow of energy supply and demand in U.S. manufacturing industries. Identifying the sources and end-uses of energy helps to pinpoint areas of energy-intensity and characterize the unique energy needs of individual industries. A generic energy footprint is shown in Figure 1.

On the supply side, the footprints provide details on the energy purchased from utilities, the energy that is generated onsite (both electricity and byproduct fuels), and excess electricity that is transported to the local grid (energy export). On the demand side, the footprints illustrate where and how energy is used within a typical plant, from central boilers to process heaters and motors. Most important, the footprints identify where energy is lost due to inefficiencies in equipment and distribution systems, both inside and outside the plant boundary. Losses are critical, as they represent immediate opportunities to improve efficiency and lower energy consumption through best energy management practices and improved energy systems.

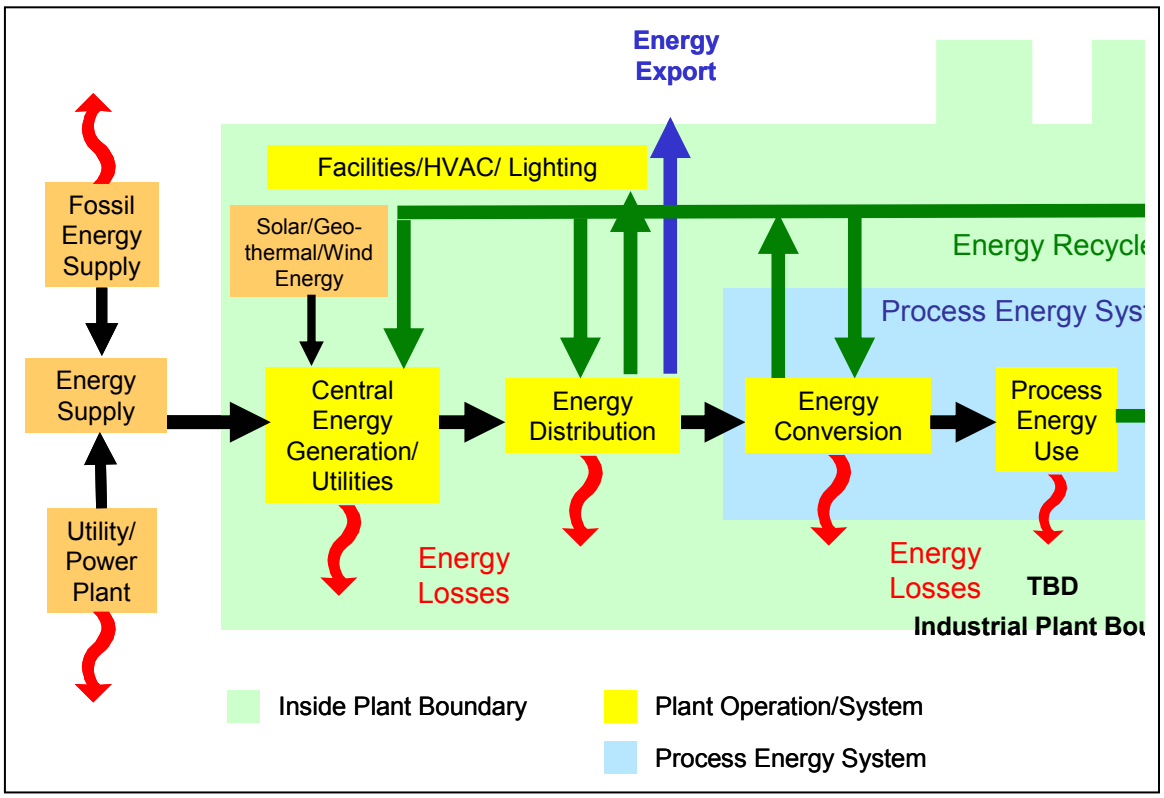

Figure 1. Generic Energy Footprint

As Figure 1 shows, the *energy supply* chain begins with the electricity, steam, natural gas, coal, and other fuels supplied to a plant from off-site power plants, gas companies, and fuel distributors. Many industries generate byproducts and fuels onsite, and these are also part of the energy supply. Notable examples are the use of black liquor and wood byproducts in pulp and paper mills, still gas from petroleum refining processes, and light gas mixes produced during chemicals manufacture. Byproduct energy is included in fossil energy supply totals. Renewable energy sources such as solar, geothermal, and wind power are shown separately.

Once energy reaches the plant (indicated by green area), it flows either to a *central energy generation utility* system (e.g., steam plant, power generation, cogeneration) or is *distributed* immediately for direct use. Central energy systems generate electricity and steam for process use, and sometimes create more energy than is needed at the plant site. When this occurs, the excess energy is exported off-site to the local grid or another plant within close proximity.

Fuels and power (see blue area) are often routed to *energy conversion* equipment that is generally integrated with specific processes. The converted energy goes to *processes* and unit operations, where it drives the conversion of raw materials or intermediates into final products.

Energy losses occur all along the energy supply and distribution system (red arrows in Figure 1. A simplified flow of losses from energy supply through industrial processing is shown in Figure 2. Energy is lost in power generation and steam systems, both off-site at the utility and on-site within the plant boundaries, due to equipment inefficiency and mechanical and thermal limitations. Energy is lost in distribution and transmission systems carrying energy to the plant and within the plant boundaries.

Losses also occur in energy conversion systems (e.g., heat exchangers, process heaters, pumps, motors) where efficiencies are thermally or mechanically limited by materials of construction and equipment design. In some cases, heat-generating processes are not optimally located near heat sinks, and it may be economically impractical to recover the excess energy. With some batch processes, energy is lost during off-peak times simply because it cannot be stored. Energy is lost from processes whenever waste heat is not recovered and when waste by-products with fuel value are not utilized.

The energy footprints represent an average picture of energy use and losses across an industry. Through them we can begin to assess the relative losses due to inefficiencies as well as sources of energy-intensity. They also provide a baseline from which to calculate the benefits of improving energy efficiency.

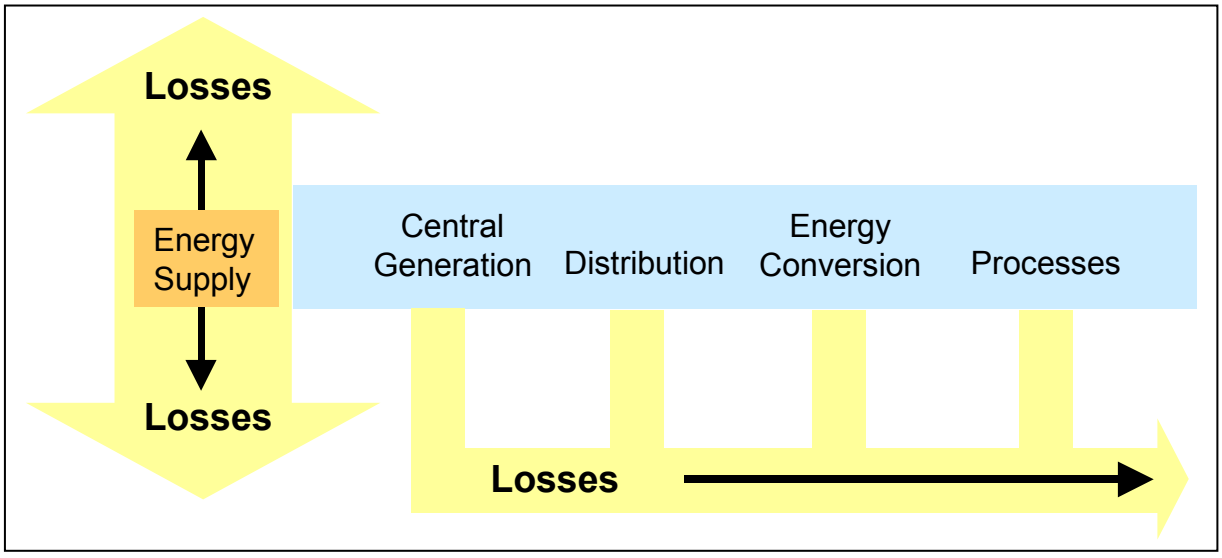

Figure 2. Simplified Flow of Energy Losses